Message

**From:** Reddy - CDPHE, Patrick [patrick.reddy@state.co.us]
**Sent:** 6/10/2015 11:31:39 PM
**To:** Irina Petropavlovskikh - NOAA Affiliate [irina.petro@noaa.gov]
**CC:** Tonnesen, Gail [Tonnesen.Gail@epa.gov]; Payton, Richard [Payton.Richard@epa.gov]; Brad Pierce [brad.pierce@noaa.gov]; Pierce', 'GORDON [Gordon.Pierce@state.co.us]; Andrew Langford-NOAA Federal [andrew.o.langford@noaa.gov]; Audra McClure - NOAA Affiliate [audra.mcclure@noaa.gov]; Christoph Senff [Christoph.Senff@noaa.gov]; pfister@ucar.edu; Scott Landes - CDPHE [scott.landes@state.co.us]; gregory.harshfield@state.co.us; huys@clarkcountynv.gov; Duncan, Bryan N. (GSFC-6140) [bryan.n.duncan@nasa.gov]; OTT, LESLEY E. (GSFC-6101) [lesley.e.ott@nasa.gov]
**Subject:** Re: Recent intrusion events

Thanks Irina,

These are helpful. We need an archivist.

I might start archiving some of these products in case we need them for event flagging.

Pat

On Wed, Jun 10, 2015 at 4:58 PM, Irina Petropavlovskikh - NOAA Affiliate <irina.petro@noaa.gov> wrote:

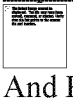
I figured I would share additional ozone maps.
For total ozone column maps I often use the CPC NCEP website (I like their coloring better than at GMAO website, more contrasting )
http://www.cpc.ncep.noaa.gov/products/stratosphere/omps/archive/nh/

For June 4th total column one can see that gradient in ozone (usually associated with the location of the subtropical or polar jets) was moving through Colorado.
So, we might be seeing the results of the airmass change with high latitude ozone airmass moving over Colorado.

at 100 mb the picture is slightly different, but again Colorado had gradient in the stratospheric ozone column change.

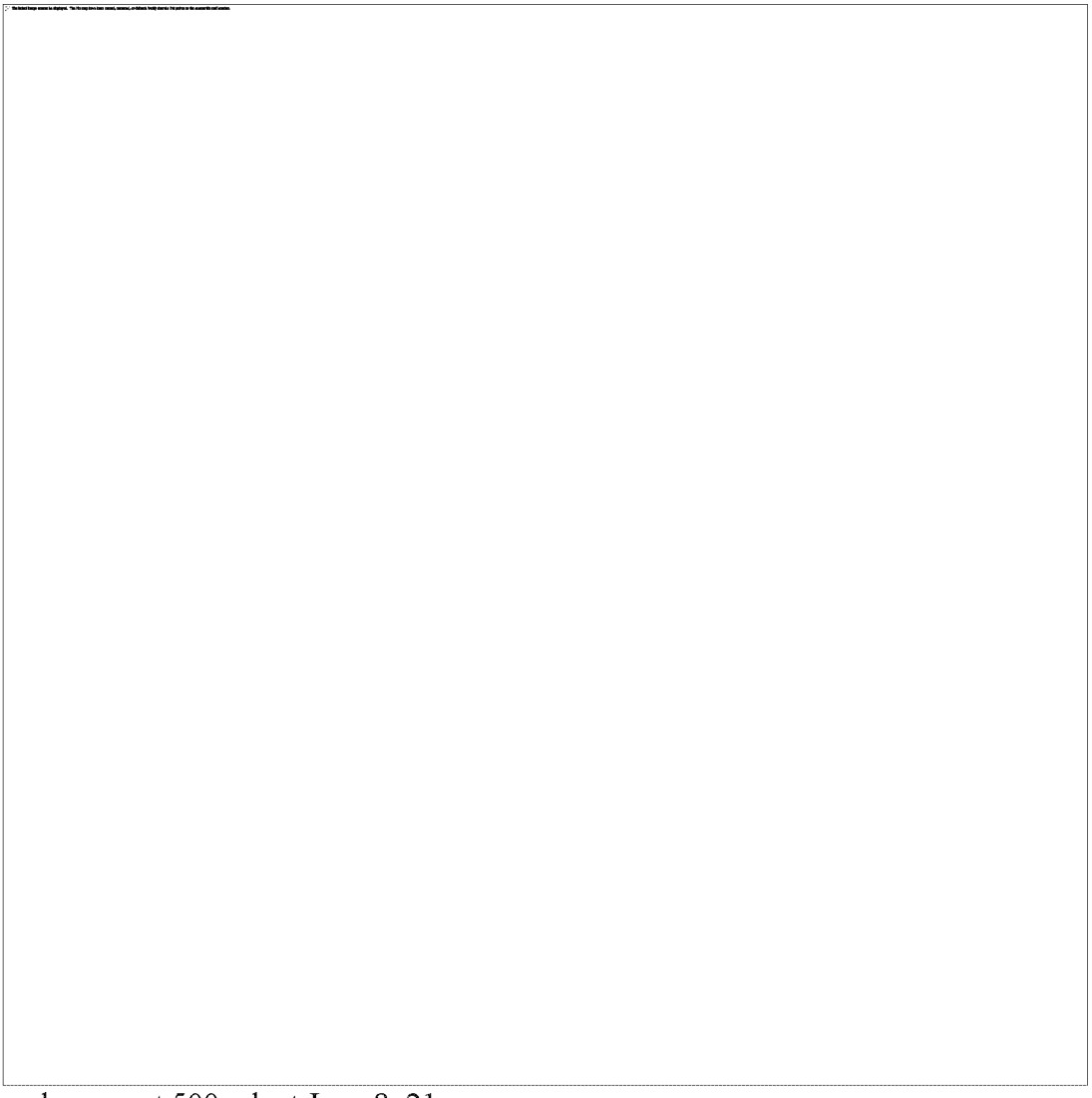
The NPP provisional ozone product shows a more detailed ozone map

http://www.cpc.ncep.noaa.gov/products/stratosphere/omps/archive/nh/omps_nh_20150607.gif

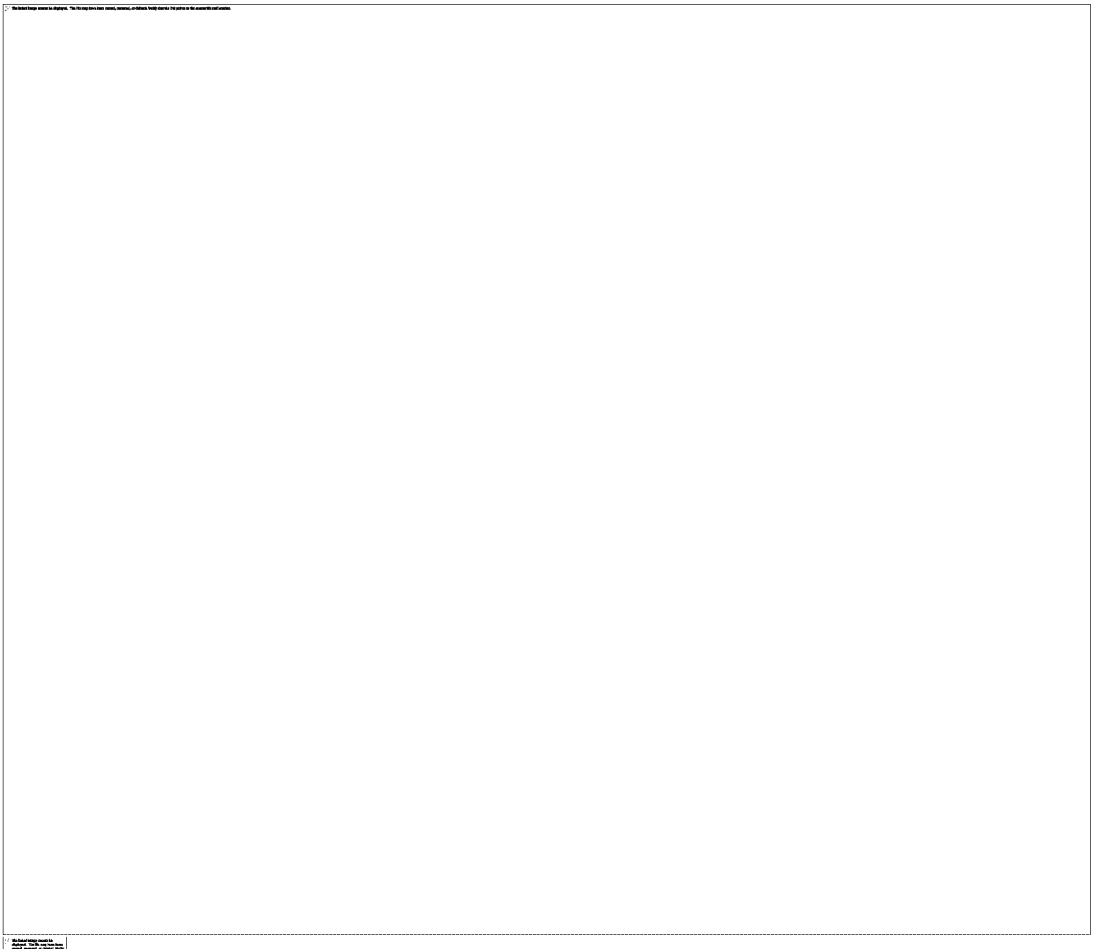


And Rapid Refresh maps of boundary height http://rapidrefresh.noaa.gov/RAP/Welcome.cgi?dsKey=rap_ncep_jet&domain=t4&run_time=08+Jun+2015+-+02Z

- I can never figure out where the Mountain research station might be on the Colorado county map. The white dot on the map for Colorado is BAO? Then to the NW is Boulder county.



and ozone at 500 mb at June 8, 21
UTC http://ruc.noaa.gov/wrf/WG11_RT/all27col.cgi?run_time_27co=07+Jun+2015+-+00Z+run



Cheers,
irina

On Tue, Jun 9, 2015 at 12:34 PM, Reddy - CDPHE, Patrick <patrick.reddy@state.co.us> wrote:

Hi all,

We have had several days with possible stratospheric O3 intrusion influences on surface concentrations in Colorado and other western states. A closed upper low around California slowly moved east and weakened, leaving an elongate zone of lowered tropopause heights, low pressure, and elevated free troposphere and total column O3 stretching from Nevada to Colorado and Wyoming where it has been affecting surface O3 for a number of days.

To complicate matters, we are in the summer anthropogenic O3 season, and we are clearly seeing contributions from anthropogenic O3 along Colorado's Front Range. To further complicate matters, there is evidence that thunderstorms have enhanced the transport or mixing of stratospheric O3 to the surface and that thunderstorms have also lowered surface O3, even while free tropospheric O3 concentrations may have shown the effects of the intrusions. This period highlights the need to use all of the tools we have to sort out the contributions of local anthropogenic O3, Asian transport, distant biomass burning, and stratospheric intrusions. In addition, with thermally-driven upslope along the Front Range and possible mountain-plains solenoids during the last few days, we need to determine whether elevated layers seen in ozonesonde or lidar data are from local sources or intrusions or both.

On June 4, we had high concentrations on the plains around Denver and at our 12,500-feet MSL Mines Peak site. Mines Peak concentrations were "cruising" at 69 to 73 ppb for the first half of the day (likely intrusion O3 background?) and then abruptly climbed to 82 ppb around 5 PM MDT. This peak period was probably associated with thermally-driven upslope adding an increment of Denver anthropogenic O3 (an extra 10 ppb?). Back trajectories for this site and time lead back to Denver. Total column O3 maps show the low over the West Coast, but do not reveal the likely streamers of stratospheric air in the troposphere in the southwesterly flow aloft out ahead of this system. I have not yet had a chance to look at all the products (IDV, RAAQMs, etc.) for this day,

At the same time, Chatfield climbed to 80 ppb around 2PM MST under upslope and Denver Cyclone conditions. Thunderstorms formed to the east. Radar data shows that an outflow boundary from these storms hit Chatfield around 3 pm, and this dropped O3 to 56 ppb by 5 PM MST. Winds behind the outflow boundary were from the southeast. So entrainment of stratospheric O3 above the evolving PBL may have enhanced the surface concentrations along the plains that may already have been high because of normal summer processes acting on local sources.

I have attached relevant plots for June 4. Intrusion effects likely continued in the multi-state region on June 5 and 6, but I will skip ahead to June 7 when a complex west-east pattern of residual high total column O3, high O3 concentrations aloft, high and low satellite water vapor, and thunderstorms was draped across northern Colorado. This pattern was an extension of the remnants of the upper low and seemed to be causing high O3 at the surface from Nevada and Utah to Colorado and southern Wyoming. Attempts to look for streamers or laminae of high IPV associated with intrusions in the area have so far not yielded much success. This may be because of the age of the system and confounding effects of storms on IPV.

During the early evening hours on June 7 an east-west oriented outflow boundary from storms near Ft. Collins, Greeley, and the Wyoming border propagated to the south. Before it generated a new line of storms to the south, it passed over our Aurora East monitor, briefly raising O3 there to 73 to 87 ppb for 3 hours. So, in this case, storms seem to have increased the transport/mixing of likely stratospheric O3 to the surface.

I had O3 forecast duties on Sunday and called for an exceedance along the Front Range for Monday. Under classic thermally-driven uplsope conditions, we saw 8-hour concentrations reach 76 ppb at Chatfield, RFLAT, and NREL on June 8. There may have been a mountain-plains solenoid, and it is possible that a residual layer of anthopogenic O3 is "mixed in" with residual stratospheric O3 in the free troposphere (last night and this morning - June 9). The Niwot Ridge data for June 8 has a late-day bump in O3 that may be associated with the arrival of urban upslope. I have attached a few more plots.

With many things happening at once, I think this period points to the need for models to help us sort out the influence of stratospheric O3 across the region.

Regards,

Pat

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**Patrick J. Reddy**
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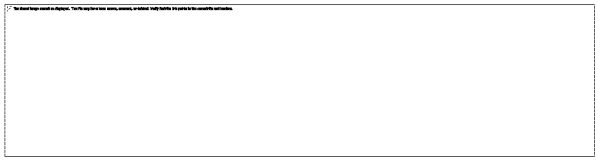

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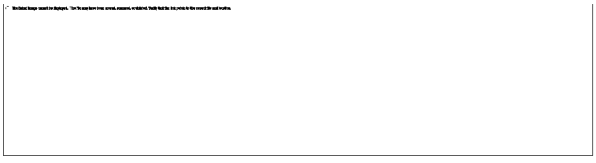

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